05863-14-P

THE UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING
DEPARTMENT OF AEROSPACE ENGINEERING
HIGH ALTITUDE ENGINEERING LABORATORY

Quarterly Report

High Altitude Radiation Measurements

1 April 1966 - 30 June 1966

FRED L. BARTMAN

FACILITY FORM 602

N67-26324	
(ACCESSION NUMBER)	(THRU)
44	1
(PAGES)	(CODE)
CR-84061	13
(NASA CR OR TMX OR AD NUMBER)	(CATEGORY)

Under contract with:

National Aeronautics and Space Administration
Contract No. NASr-54(03)
Washington, D. C.

Administered through:

April 1967

OFFICE OF RESEARCH ADMINISTRATION • ANN ARBOR

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ABSTRACT

This report summarizes project activity during the period 1 April, 1966 to 30 June, 1966. A model of stratocumulus cloud reflectance, based on 2 June, 1962 data, extrapolated by comparison to results of a single scattering theory, is presented. Reflectance scatter diagrams, which provide information about the spectral variation of reflectance of earth surface features, are discussed.

Problems encountered during the final testing and calibration of the interferometer spectrometer are discussed. Balloon flight preparations and field operations for three balloon flights at Palestine, Texas are described. An initial evaluation of data obtained on the 8 May, 1966 balloon flight is presented.

I. INTRODUCTION

This is the 14th Quarterly Progress Report on Contract No. NASr-54(03) covering the period 1 April, 1966 to 30 June, 1966. The project effort during this time period was divided among the following tasks:

1. Analysis of data from previous balloon flights.
2. Development of an infrared interferometer for spacecraft use.
3. Balloon flight preparations and field operations.
4. Initial analysis of balloon flight data.

II. ANAYLSES OF DATA FROM PREVIOUS BALLOON FLIGHTS

A. MODEL OF STRATOCUMULUS CLOUD REFLECTANCE

A model of the reflectance of a stratocumulus cloud has been constructed from data obtained on the 2 June, 1962 balloon flight, extrapolated by comparison with Deirmendjian's[1] calculation for single scattering in a water cloud model. The average data for the 0.55-0.75-micron channel and the 0.2-4.0-micron channel of the TIROS 103 radiometer are shown in Figure 1 along with the theoretical results of Deirmendjian.

While the single scattering model does not produce the intensity of the actual cloud scattering, the qualitative agreement of the functional relationship should be noted, even to the existance of the maximum of the curve at $\beta = 136°$ (i.e., the fogbow). This angle is less than the theoretical angle of 143° for $\lambda = 0.70$.

Since data was obtained only for $50° < \beta < 145°$ the curve has been extrapolated from 50° to 0° and from 145° to 180° using the theoretical curve as a guide. This final curve, also shown in Figure 1, is a final estimate of the scattering pattern of a stratocumulus cloud for high solar zenith angles. A three-dimensional model of this scattering pattern is shown in Figure 2. In this figure, the flat circular disk represents the top of a flat cloud. Solar radiation is incident from the right at an elevation angle of 20°. The spike in the scattering pattern pointing to the right is backscattering. The fogbow is the next "scallop" in the pattern. The large amount of forward scattering is shown at the left. The truncation of this forward scattering is merely due to the limit in the size of the model. The small bow in the center of the pattern may possibly be due to noise. Deirmendjian's calculations show that this bow exists at 5.3 microns but not at lower wavelengths.

Note that the complete scattering pattern is a figure of revolution having the ray of incident solar radiation as axis, and that the bireflectance pattern of the cloud is obtained by merely cutting the scattering pattern with a plane, as in Figure 2, so that the correct angle of incidence is obtained. Thus it is obvious, that the total directional reflectance of such a cloud is a function of the elevation angle of the sun, and can be calculated by integrating over the hemisphere above the plane.

This has been done for the scattering model shown in Figure 2 with the result shown in Figure 3, which shows total directional cloud reflectance as a function of the solar angle of elevation. The total directional reflectance has a minimum value of 58% at a solar elevation angle of 40°, and a maximum of 85% at 0° elevation angle. These results are in agreement with those of other experimenters; i.e., Neiburger[2] obtained total reflectances of 70-80% for a 1800-foot thick stratocumulus cloud (solar elevation angle not noted).

B. REFLECTANCE SCATTER DIAGRAMS

Although the data for much of this balloon flight cannot be used to plot bidirectional reflectance or scattering diagrams, it does provide some information about the spectral dependence of reflectances measured. Values of the radiometer measurements taken simultaneously by the two channels of the radiometer are plotted in a modified scatter diagram in Figure 4, i.e., the ratio of the bidirectional reflectance of the wide-band channel, ρ'_3, divided by the bidirectional reflectance of the narrow-band channel, ρ'_5, is plotted vs. ρ'_5 .

The data samples were taken at 4.5-minute intervals throughout the day, so that the diagram shows samples of data taken at different scattering angles and for different cloud conditions. The diagram shows that for the most part, channel 3(0.2-5.5 microns) reflectances are greater than channel 5(0.55-0.75 micron) reflectances, with the ratio being approximately equal to 1 at high reflectances and as high as 2 for low values of reflectance. This diagram provides additional evidence that the narrow-band channel data cannot be used for earth albedo calculations, and that if it is so used a value of earth's albedo which is too small will be obtained (as was obtained by Bandeen[3]). Given Bandeen's data a correction factor for his earth's albedo could be calculated from a curve such as shown in Figure 4.

In Figure 5 the reflectance ratio is plotted as a function of time during the balloon flight. A general description of the scene viewed is given along the bottom of the figure for correlation with the reflectance ratio. When the radiometer views the stratocumulus cloud, the reflectance ratio is very close to 1. However, early in the morning when the sun is at a very low elevation angle ($< 8°$), the ratio is considerably less than 1; and late in the day, when the radiometer is looking through scattered clouds at the earth, the ratio is much greater than 1. This change of the ratio during the day is consistant with a spectral distribution containing primarily short wavelength scattered radiation in the morning, roughly equal intensities at all wavelengths when looking at stratocumulus with the sun above 8°, and increased reflectance at wavelengths above 0.75 micron when looking at the earth through scattered clouds in the afternoon.

Similar results were obtained on the 26 June, 1963 balloon flight. Curves of the reflectance ratio ρ'_3/ρ'_5 vs. ρ'_5 were obtained by both the TIROS 103A and NIMBUS MRIR F-1 radiometers.[5] These data are shown in Figures 6 and 7, respectively. They show a functional relationship similar to that shown by the TIROS 103A radiometer on the 2 June, 1962 balloon flight, with $\rho'_3 > \rho'_5$ for low values of ρ_5' and $\rho_3' \approx \rho_5'$ for high values of ρ_5'. The TIROS radiometer data show $\rho_3'/\rho_5' = 1.0$ at $\rho_5' = 90$, whereas the NIMBUS radiometer data show the ratio = 0.8 at this value of ρ_5'. The difference may be due to calibration errors (the calibration of the narrow-band channel of the F-1 radiometer is uncertain because of filter deterioration). At any rate the data bear out the conclusion that the narrow-band channel data cannot be used to infer earth albedo values without the use of a correction factor derived from curves such as Figures 4, 6, and 7.

Reflectance ratios have been plotted as a function of time for this balloon flight in Figures 8 and 9. Again the general nature of the terrain viewed is indicated at the bottom of the figure. When the radiometers view the high clouds at the end of the flight the reflectance ratio is close to 1, however, for clear sky conditions earlier in the flight, the ratio is as high as 3.5, due to the fact that the reflectance of the earth is greater in the long wavelength region. The ratio for clear skies decreases with increasing sun angle as we should expect, because of a decrease in scattered short wavelength radiation.

III. DEVELOPMENT OF AN INFRARED INTERFEROMETER FOR SPACECRAFT USE

This three-month interval was a period of testing, calibration, and modification in preparation for the balloon flight. The following is a brief description of the significant events in chronological order.

During the first few days of April three changes were made in the instrument as a result of attempts to calibrate at Bendix System Division. The changes were:

1. The calibration targets were moved closer to the instrument aperture so that they would fill the larger field of view obtained by changing to the old Block I-4 detector (all other detectors had been sent to Barnes Engineering Co. for repairs).

2. The gain changing circuit was changed to give a 4:1 instead of 10:1 ratio. This was done to reduce the offset error produced by a different zero offset in the amplifier for the two different values of gain.

3. Foam insulation was placed around the instrument aperture to correct for excessive heat loss.

The first series of environmental tests were then carried out at Chrysler Missile Division on April 4-6. The complete gondola was tested. Four difficulties were encountered in the operation of the interferometer. These difficulties and the corrections made after returning to Ann Arbor were:

1. Excessive noise in the signals due to the arcing of serial motors and the operation of cameras on the balloon gondola. Additional filtering reduced the noise to a barely acceptable level.

2. The gain switching circuit failed to operate when a signal in excess of full scale was applied to the A-D converter. The switching ratio was changed back to 10:1 and the zero offset error was minimized by a new adjustment technique involving a simulated interferogram signal.

3. A fractured line in the 4-liter liquid N_2 cooling system prevented proper cooling of the interferometer. The plastic tubing used was shortened and clamped more securely.

4. The biphase signal circuitry failed near the end of the test, during the simulation of the gondola descent. All A-D converter boards were coated with plastic.

A procedure was developed for inspecting the digital signal output of the interferometer. The magnetic tape recording is played back at slow speed and recorded on a CEL direct writing recorder operating at high speed. The digital signals are visually decoded and plotted on a graph for detailed inspection. Although the procedure is time consuming, the final results are excellent. By this method it was determined that the noise due to camera operation was not of serious interference.

A second series of environmental tests were carried out at Chrysler Missile Division on April 10-12. Two major problems were encountered and solved.

1. A valve in the liquid N_2 system froze and prevented proper temperature control. The valve was moved to a different part of the system.

2. The Block I-4 detector became intermittantly noisy and was replaced by an open flake detector which had been repaired at Barnes Engineering Co.

The preliminary calibrations were completed on April 12. The remainder of the balloon flight preparations were carried out at Palestine, Texas and are described in the next section of this report.

IV. BALLOON FLIGHT PREPARATIONS AND FIELD OPERATIONS

A. FINAL TESTS AT THE UNIVERSITY OF MICHIGAN

Final tests of the entire balloon gondola were carried out before the environmental test at Chrysler Missile Division. Two difficulties encountered were corrected. A slight amount of intermodulation between telemetry subcarriers was corrected by adjusting the pre-emphasis. A malfunction of the programming logic which prevented proper calibration of the telemetry was corrected. Interferometer problems are described above.

B. ENVIRONMENTAL TESTS AT CHRYSLER MISSILE DIVISION

The environmental test of the entire gondola was held at Chrysler Missile Division on April 4-6. On April 4, all equipment was installed in the test chamber. The test was run on April 5, and the equipment was removed from the chamber on April 6.

The purpose of this test was to provide a short period of operation of all equipment under simulated balloon flight conditions. Although air pressure and temperature variations were simulated realistically, environmental conditions were not accurately simulated because of the lack of control of the chamber relative humidity and because solar radiation was not simulated accurately. The test chamber conditions are summarized in Table I. Other test conditions should be noted. Neither the free air temperature thermister booms nor the spin jets were tested as they would be used during the flight. A transmitting antenna was installed in the chamber to test for RFI under a 240.2 mhz field somewhat greater in magnitude than would be encountered under normal flight conditions.

Interferometer difficulties during this test have been noted above. In addition, battery compartment temperatures slightly lower than desirable indicated that additional insulation should be provided.

With the successful conclusions of this test and after the success of additional interferometer tests on April 10-12, all equipment and personnel were transported to Palestine, Texas for the balloon flight operations.

TABLE I

TEST CONDITIONS FOR 5 APRIL, 1966 ENVIRONMENTAL TEST

Time		Altitude,	Temperature		Program
EST	Minutes	10^3 feet	°C	°F	Function
1309:47	0	Ambient	20	68	Camera 1 Door Closed
	10	Ambient	20	68	
	20	Ambient	10	50	
	30	Ambient	0	32	
	40	Ambient	-10	14	
	50	10	-20	- 4	
1409:47	60	20	-35	-31	Sun Mirror
	70	30	-50	-58	
	80	40	-60	-76	
	90	50	-60	-76	
	100	60	-55	-67	
	110	70	-50	-58	
1509:67	120	80	-45	-49	Cameras 2, 3, 4
	130	90	-40	-40	
	140	100	-35	-31	
	150	105	-30	-22	
	160	105	-30	-22	
	170	105	-30	-22	Inst. Doors Open
1609:47	180	105	-30	-22	
	190	105	-30	-22	
	200	105	-30	-22	
	210	105	-30	-22	
	220	100	-35	-31	Inst. Doors Closed
	230	80	-40	-40	
1709:47	240	60	-40	-40	
	250	40	-15	5	
	260	20	15	59	
	270	10	20	68	
1749:47	280	0.5	25	77	

C. TELEMETRY TEST FLIGHT

Balloon flight operations were begun on 14 April. Assembly and test operations on the main gondola were started. The assembly and test of a small telemetry test package was completed by 18 April; however, surface weather was not suitable for a balloon launch until April 27. This preliminary test flight (NCAR flight 213-P) was released at 0525 CST on 27 April under clear skies. High-surface winds (12 knots) resulted in 3 attempts before a successful launch was achieved. The Raven Industries 250,000 cubic foot balloon rose to a float altitude of 101,400 feet at an average ascent rate of 918 feet per minute.

Although the telemetry antenna was pulled off of the package during the rough launch operations, data was obtained for two hours after the balloon reached float altitude. Partial test flight results were obtained. All telemetry ground stations were found to be in good working order. Data on telemetry range with known power outputs was not obtained because of the loss of the antenna. The balloon configuration, altitude vs. time curve, trace of balloon trajectory on the earth, and free air temperature data for this flight are shown in Figures 10-13. A summary of balloon weight data is given in Table II.

TABLE II

WEIGHT AND LIFT DATA FOR TELEMETRY TEST FLIGHT
(Flight 213-P, 27 April 1966)

		lb
Balloon (Raven 2333-545-386)		88.0
Parachute (24-Foot Diameter)		23.0
Balloon Control Instruments (Radio beacon, barocoder, safety timer, photobarograph, command receiver and decoder)		61.0
Scientific Payload		13.0
	Gross Weight	185.0
	Free Lift, 15%	28.0
	Gross Lift	213.0

D. BALLOON FLIGHT OF INFRARED INSTRUMENTS

The final assembly and testing of the large gondola was carried out concurrently with the telemetry test payload. Several problems developed in the course of this work and were solved without exceptional difficulty.

The 110 volt AC 60-cycle power supply to the bus was found to be much too low in voltage. Wiring changes corrected this and eliminated a high bus to earth voltage. The photocell field of view was adjusted slightly.

Interferometer field of view measurements were carried out on 18 April. Preliminary check outs of the complete gondola were carried out on 19, 20, and 21 April. On 22 April the interferometer detector was found to be intermittantly noisy. On the basis of previous experience it was felt desirable to continuously maintain the instrument at 0°C and eliminate temperature cycling from 0°C with ambient temperature.

The instrument was kept at 0°C with ambient air pressure until 24 April when it was placed in the NCAR environmental test chamber at low pressure.

Flight proceedures were begun on 28 April, 3 May, and 4 May, but cancelled because of high surface winds, ground fog and/or bad weather predicted for the impact site.

The flight (NCAR 214-P) was launched on 8 May, 1966 at 0553 CST under ideal weather conditions. The 2.94 million cubic foot Winzen balloon ascended to the float altitude of 108,100 feet an average rate of 1006 feet per minute. It remained at altitude for 7.5 hours. The flight was terminated by radio command at 1520 CST, with a resulting parachute descent to impact 23 miles west of Leona, Texas at 1618 CST.

TABLE III

WEIGHT AND LIFT DATA FOR INFRARED MEASUREMENTS FLIGHT
(Flight 214-P, 8 May 1967)

		lb
Balloon (SF-199.78-100-NS-01) Winzen		677.0
Parachute (64 Foot Diameter)		75.0
Bottom Box (Radio beacon, barocoder, safety timer, photobarograph, radio command receiver and decoder)		40.0
Top Box (Radio beacon, barocoder, radiosonde transmitter)		23.0
Scientific Payload		680.0
Ballast		100.0
	Gross Weight	1595.0
	Free Lift, 10%	159.0
	Gross Lift	1754.0

The balloon configuration, altitude vs. time curve, trace of balloon trajectory on the earth, free air temperature data during ascent and program of functions and signals for this balloon flight are shown in Figures 14-18. A summary of balloon weight data is given in Table III.

The flight was partially successful. Good data were obtained for the interferometer. The filter wedge spectrometer and MRIR radiometer data were only partially complete.

Two primary failures occurred with major effect on the data. The free air temperature (FAT) boom cable snapped at launch and allowed the boom to swing down into the path of the MRIR door. About an hour and a half after launch, when the MRIR door started to open, a sharp corner of the door caught in the FAT boom: the door jammed. The stalled motor eventually burned out. The MRIR door was only partially open and so partial data from only 3 channels was obtained.

One hour after launch the other primary failure occurred. A Ledex stepping relay failed in the calibrate-monitor circuit. From this time, throughout the remainder of the flight, there were no further telemetry calibrations, and only a small portion of the housekeeping data was telemetered to the ground. This failure occurred at approximately the time that the surface tracking radar was turned on to track the balloon, however it is not possible to determine whether or not this was the cause of the failure. After the flight, it was determined that the basic failure was a transistor in the relay driver circuit.

There was a failure of the 110-volt AC 60-cycle power at 0916 CST, when the entire NCAR power supply failed. However, only a few minutes of signals were lost during the time it took to start the bus's Onan generators and switch to mobile operation.

A summary of results obtained on this balloon flight is given in Table IV.

TABLE IV

SUMMARY OF RESULTS, 8 MAY, 1966 BALLOON FLIGHT

1. Interferometer: good data throughout flight.

2. Filter wedge spectrometer: data from spectrometer throughout flight: no calibrations above 60000 feet since blackbody and bolometer temperatures were not obtained.

3. MRIR: data for part of scan on 3 channels.

4. Photocell azimuth data: good data throughout flight.

5. Housekeeping data: only a small portion.

6. Telemetry: solid throughout flight.

7. Cameras:

    a. 1, seven hours of operation, shutter light leak after 3 hours.
    b. 2, nine hours of operation, timing uncertain after 2.5 hours.
    c. 3, camera jammed shortly after launch.
    d. 4, nine hours of operation, shutter light leak after 4 hours.

E. JOINT OPERATION WITH JPL

After the 8 May balloon flight preparations were made for the second major infrared instrument balloon flight on this field trip, a joint operation with

JPL. On this flight two JPL instruments were flown along with the filter wedge spectrometer and the MRIR radiometer. The JPL instruments were the 4.2-micron infrared multidetector spectrometer (IRMS) and the 4.2-micron infrared scanning spectrometer (IRSS).

All equipment which failed on the 8 May balloon flight was repaired, and preliminary testing of the instruments was begun. An extensive series of RFI tests were conducted on 15 May and the gondola was ready for flight on 16 May. Final flight preparations were begun on the mornings of 20, 22 and 25 May, but were cancelled because of high surface winds.

The launch operations were finally carried out on 26 May. The balloon (NCAR flight 216-P) was released from the inflation spool at 0200 CST. The release line cutters failed to operate and the scrim balloon spread out into a large spinnaker sail, inducing large forces on the restraining line, which eventually broke. The gondola was dragged, bouncing, along the ground and smashed into a large A frame. This impact severed the load line and demolished the gondola.

The rugged construction of the gondola provided good protection for the equipment. Table V is an evaluation of the condition of all University of Michigan equipment made after the disaster. Table VI is a weight summary for this balloon flight. Figure 19 is a photograph of the result of the launch disaster. The balloon gondola is lying at the bottom of the A frame.

TABLE V

CONDITION OF EQUIPMENT AFTER BALLOON FLIGHT

1. MRIR

   Scanner - apparently undamaged.
   Electronics - chassis has several small ruptures.
   Cables - torn badly, complete loss.
   Power supply box - badly damaged but repairable.

2. Filter Wedge

   Optical instrument - dents in enclosure, operates satisfactorily.
   Demodulator - severe bending, operates satisfactorily.

3. Cameras

   All cameras except camera 1 damaged but repairable, camera 1 operates satisfactorily.

4. Electrical controls and cables - complete loss.

5. Yardney silver cells - apparently undamaged.

6. Gondola - complete loss - replaced by JPL.

7. MRIR box and door - badly damaged, some parts salvageable.

8. FAT booms and motor - some parts salvageable.

9. Photocell azimuth indicator - destroyed.

TABLE VI

WEIGHT AND LIFT DATA FOR JOINT OPERATION WITH JPL
(Flight 216-P 26 May 1966)

	lb
Balloon ($3.2 \cdot 10^6$ GT-11, Schjeldahl)	1461
Parachute (64-Foot Diameter)	74
Scientific Payload plus Ballast and Some NCAR Instrumentation	1010
Additional Ballast	30
Cable	51
Top Box	27
Bottom Box	38
Gross Weight	2691
Free Lift, 9%	242
Gross Lift	2933

V. INITIAL DATA EVALUATION FOR 8 MAY, 1966 BALLOON FLIGHT

Selected portions of the interferometer data were checked visually as described above before leaving Palestine, Texas. Results were excellent.

Back at The University of Michigan interferograms recorded just before and immediately after the door was opened were transformed to spectra. The difficulty of determination of the interferogram zero phase point when viewing a target with positive and negative radiances was solved by trial and error. The first spectra were obtained on 31 May. The spectra were examined carefully and all absorption lines were identified. The information was transmitted to GSFC and discussed with Dr. Hanel on 21 June.

The 8 May flight path was determined from the camera 2 photos (see Figure 16). Filter wedge data records were sent to GSFC for examination, the analysis of photocell azimuth data and MRIR data was begun.

VI. FUTURE WORK

The primary effort during the next work period will be devoted to:

1. Post flight testing and calibration of the interferometer and MRIR radiometer.

2. Repair of equipment and construction of new balloon control instrumentation.

3. Data analyses.

4. Report writing.

VII. REFERENCES

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2. Neiburger, M., "Reflection, Absorption and Transmission of Insolation by Stratus Clouds," J. Meteor., 6, 98-104 (1919).

3. Bandeen, W.R., Halev, M., and Strange, I., "A Radiation Climatology in the Visible and Infrared from the TIROS Meteorological Satellites," NASA TN D-2534, National Aeronautics and Space Administration, Washington, D.C.

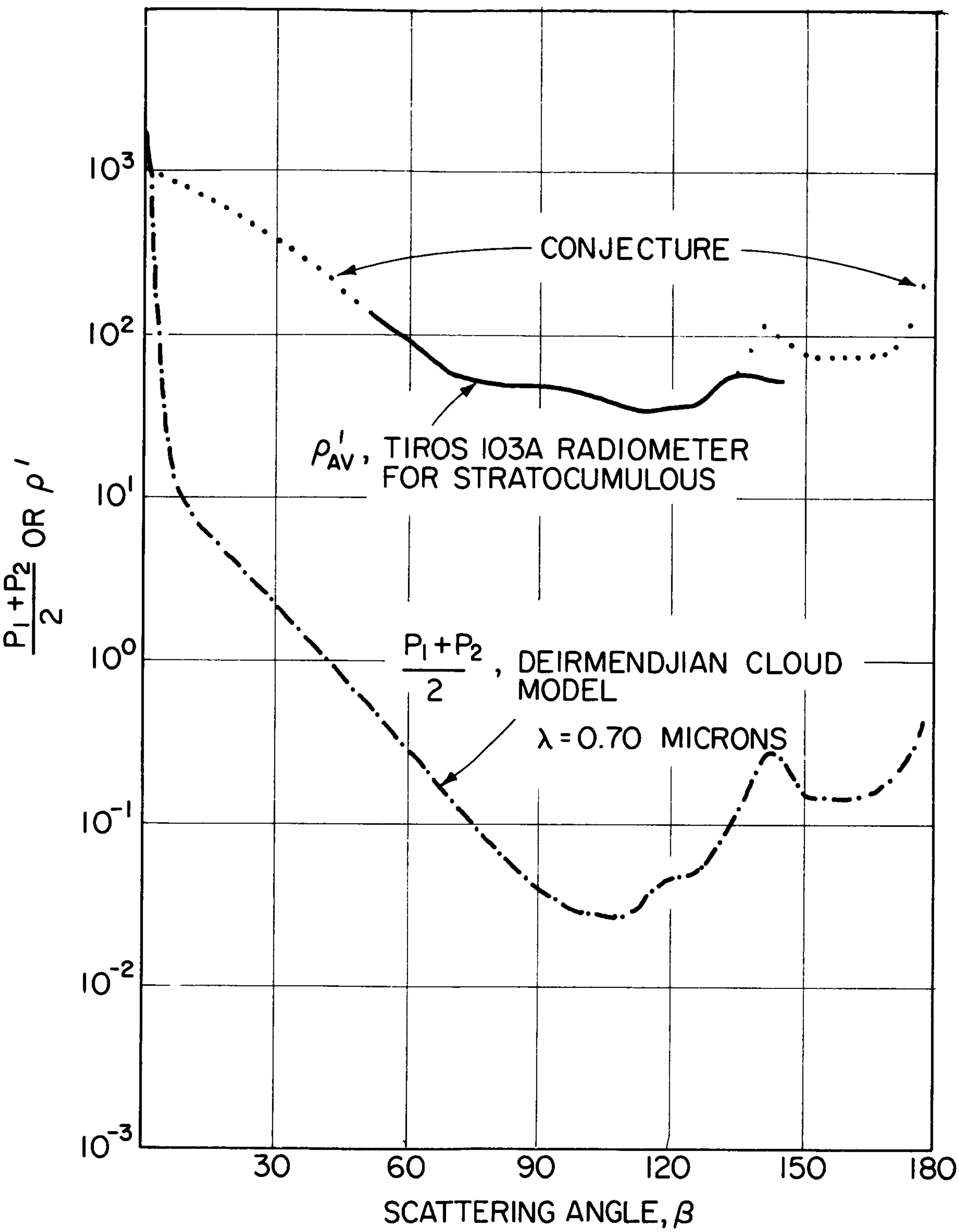


Figure 1. Comparison of experimental measurements of bidirectional reflectance of stratocumulus cloud with theoretical single scattering pattern of water cloud model.

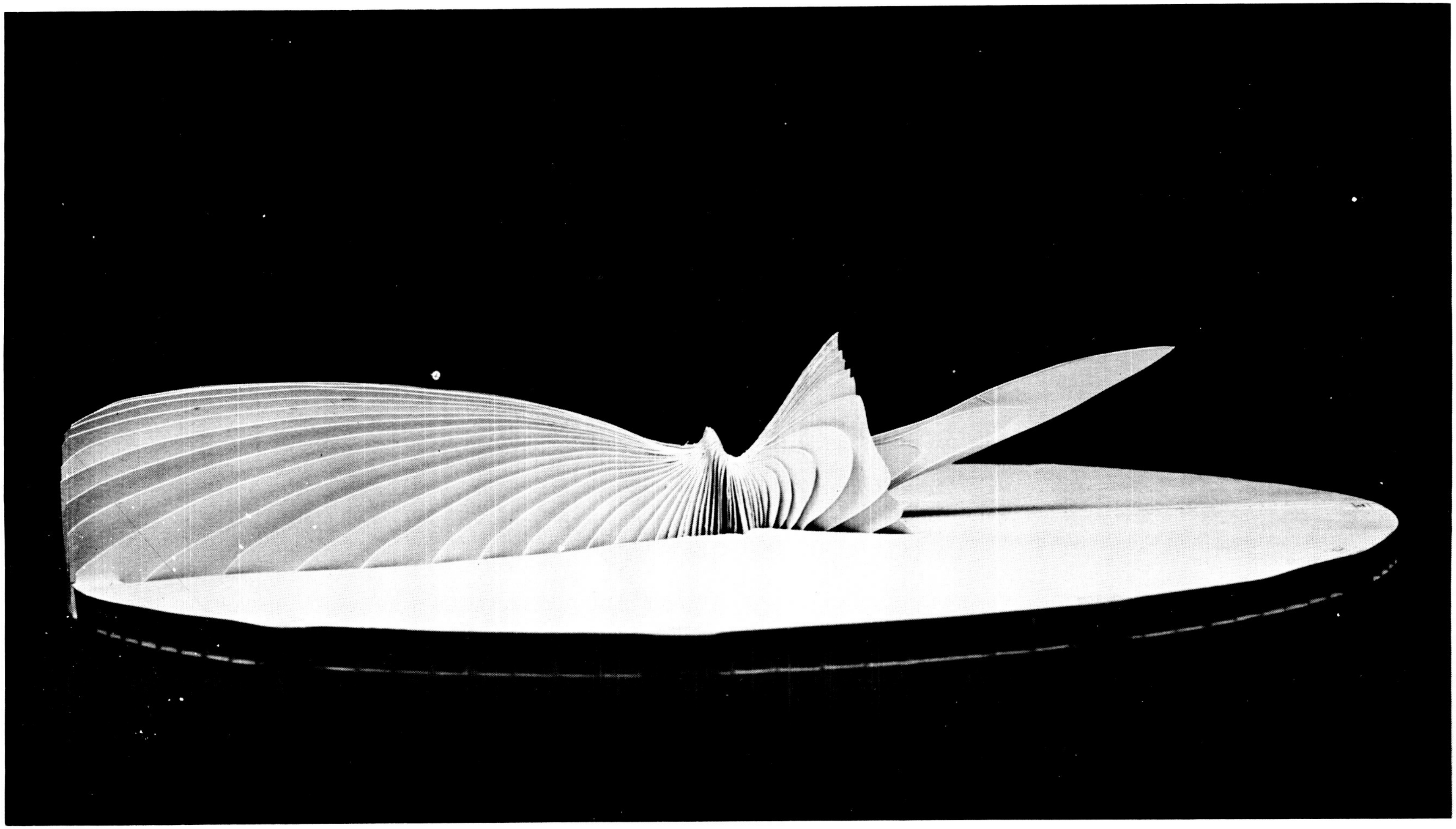


Figure 2. Model of bidirectional reflectance pattern of stratocumulus cloud.

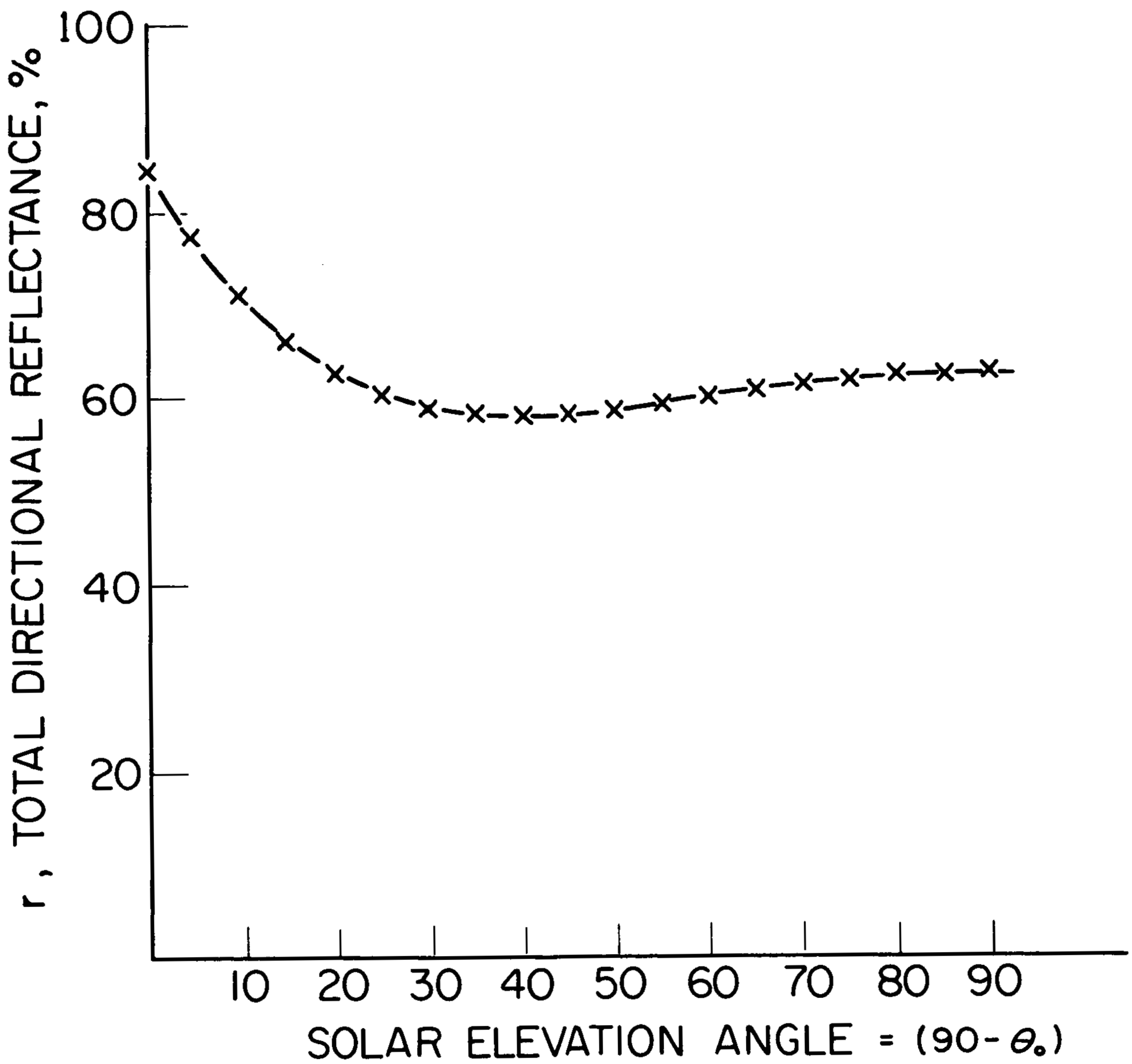


Figure 3. Total directional reflectance of a stratocumulus cloud as a function of solar angle of elevation.

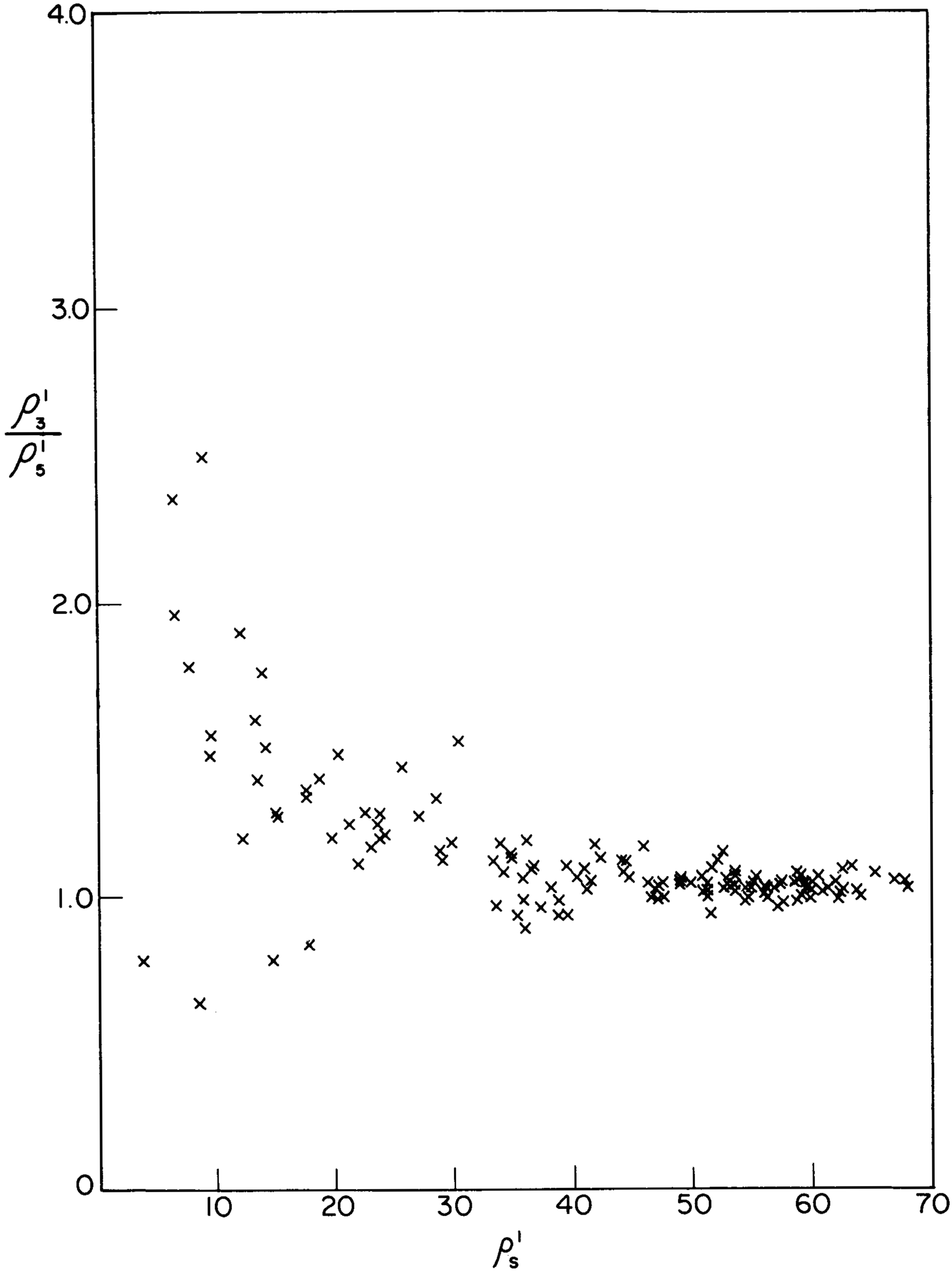


Figure 4. Reflectance diagram, ratio ρ_3'/ρ_5' vs. ρ_5' for 2 June, 1962 balloon flight. All data taken above complete overcast or broken to scattered cloud conditions.

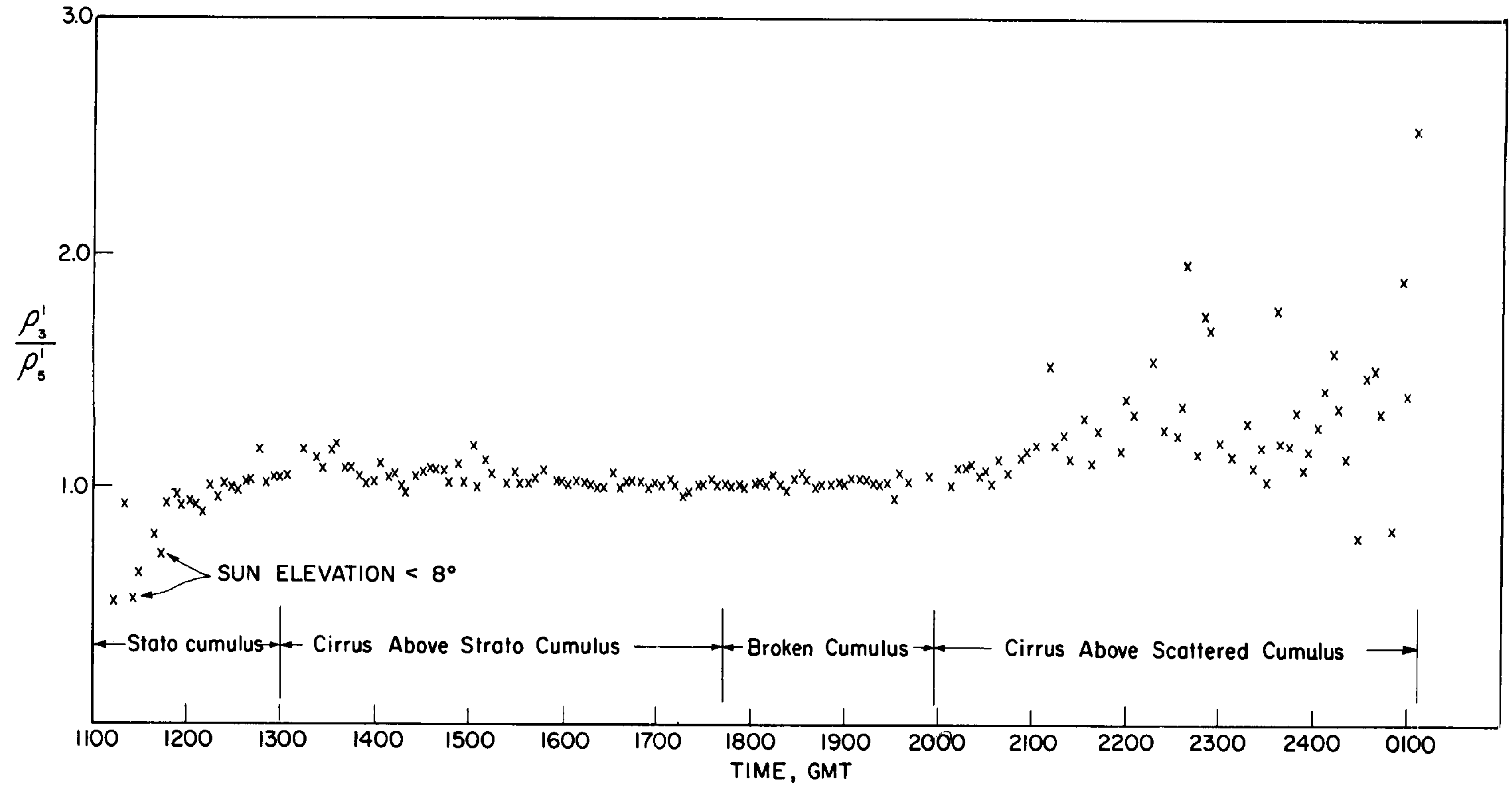


Figure 5. Reflectance ratio vs. time for 2 June, 1962 balloon flight.

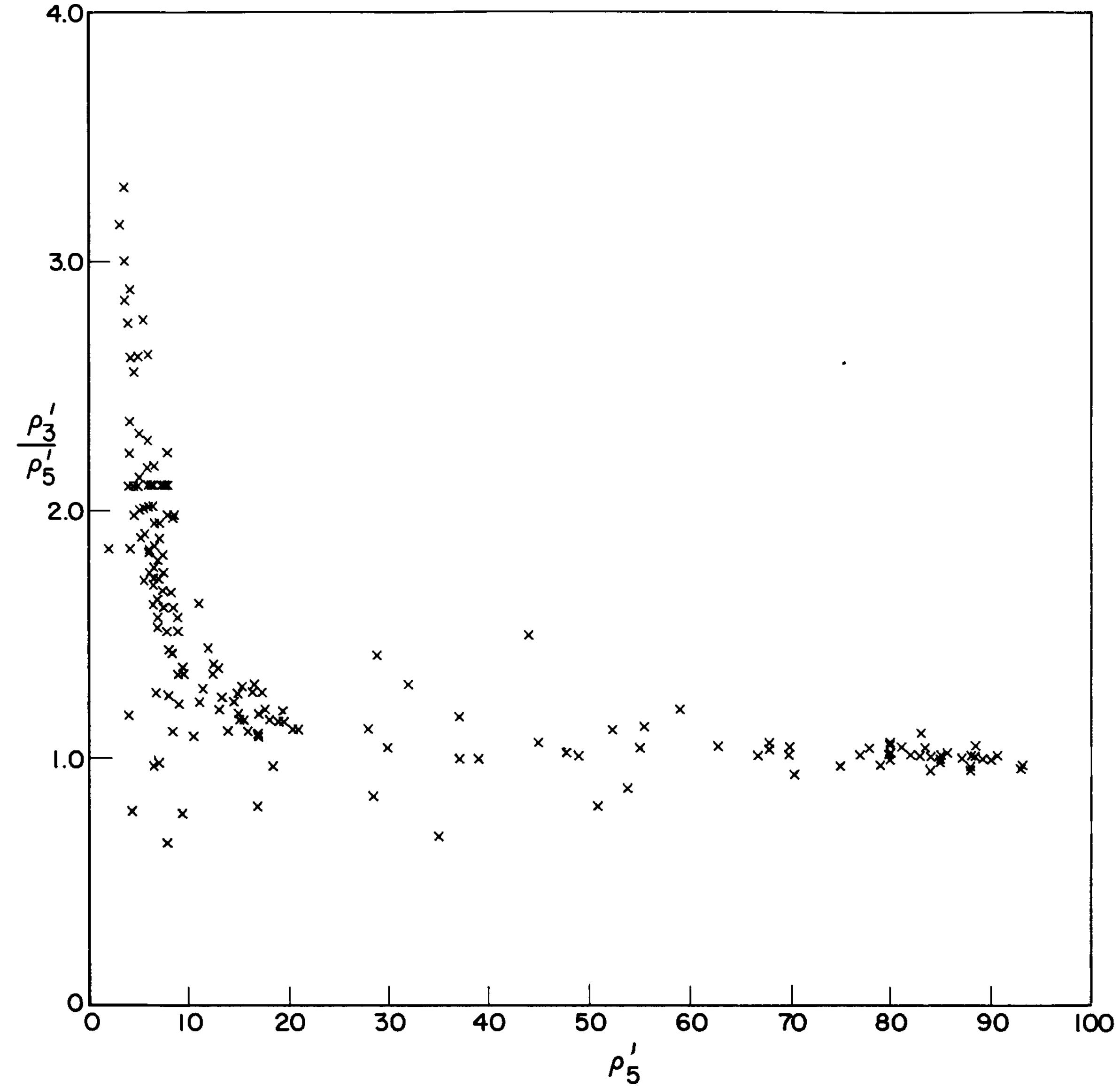


Figure 6. Reflectance diagram, ratio ρ_3'/ρ_5' vs. ρ_5' for 26 June, 1963 balloon flight, TIROS 103A radiometer.

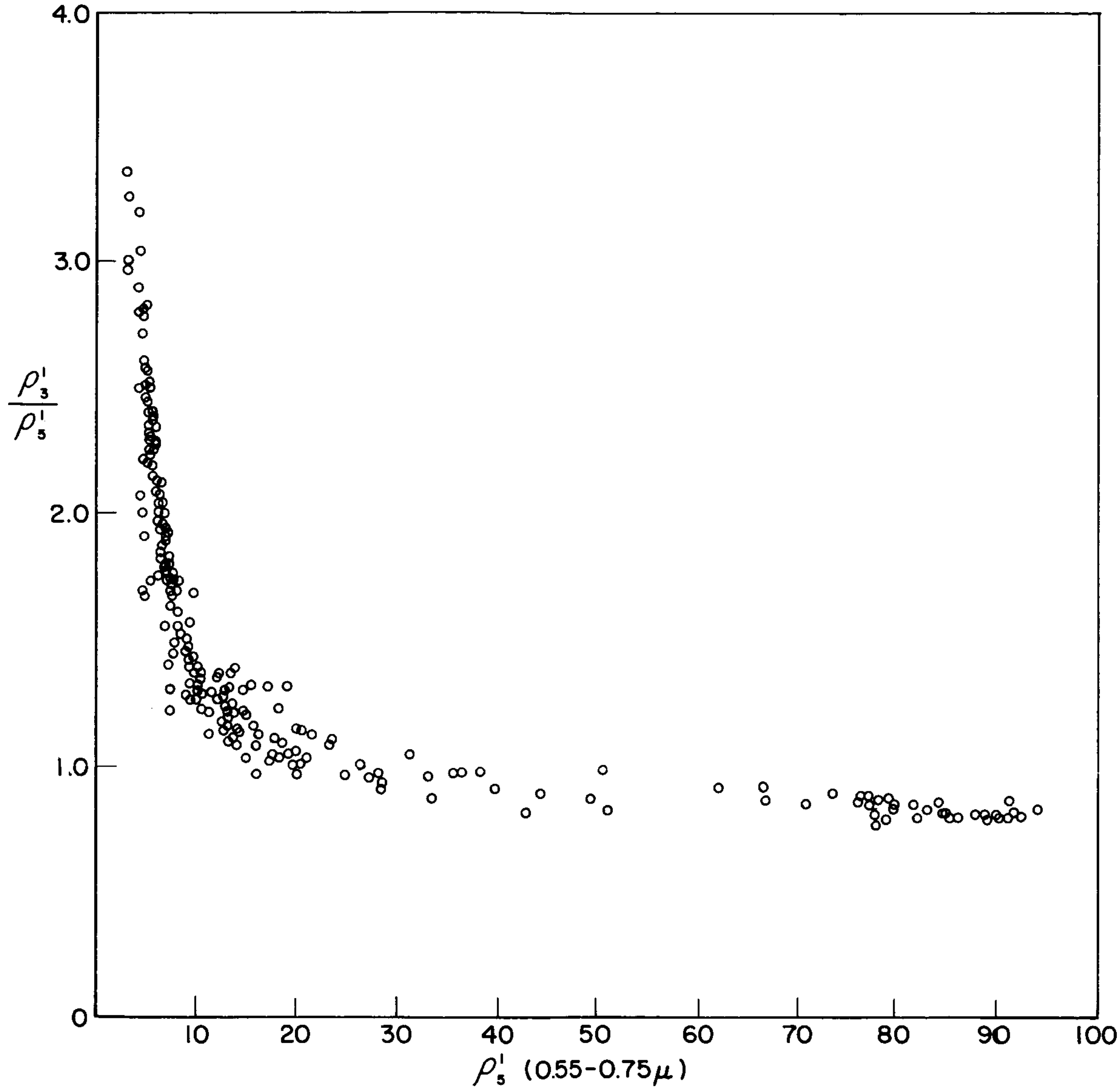


Figure 7. Reflectance diagram, ratio ρ_3'/ρ_5' vs. ρ_5' for 26 June, 1963 balloon flight, NIMBUS-MRIR F-1.

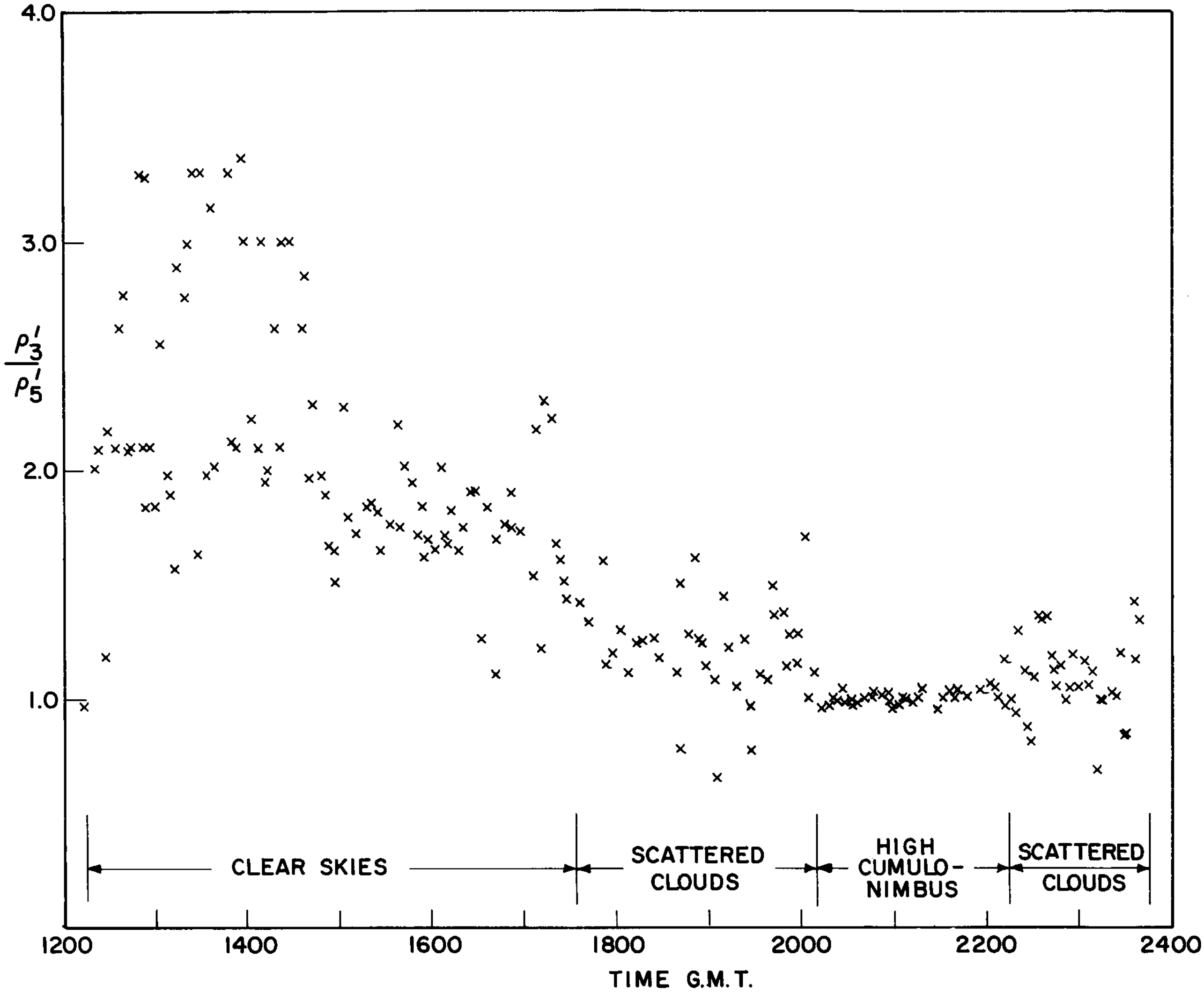


Figure 8. Reflectance ratio vs. time for 26 June, 1963 balloon flight TIROS 103A radiometer.

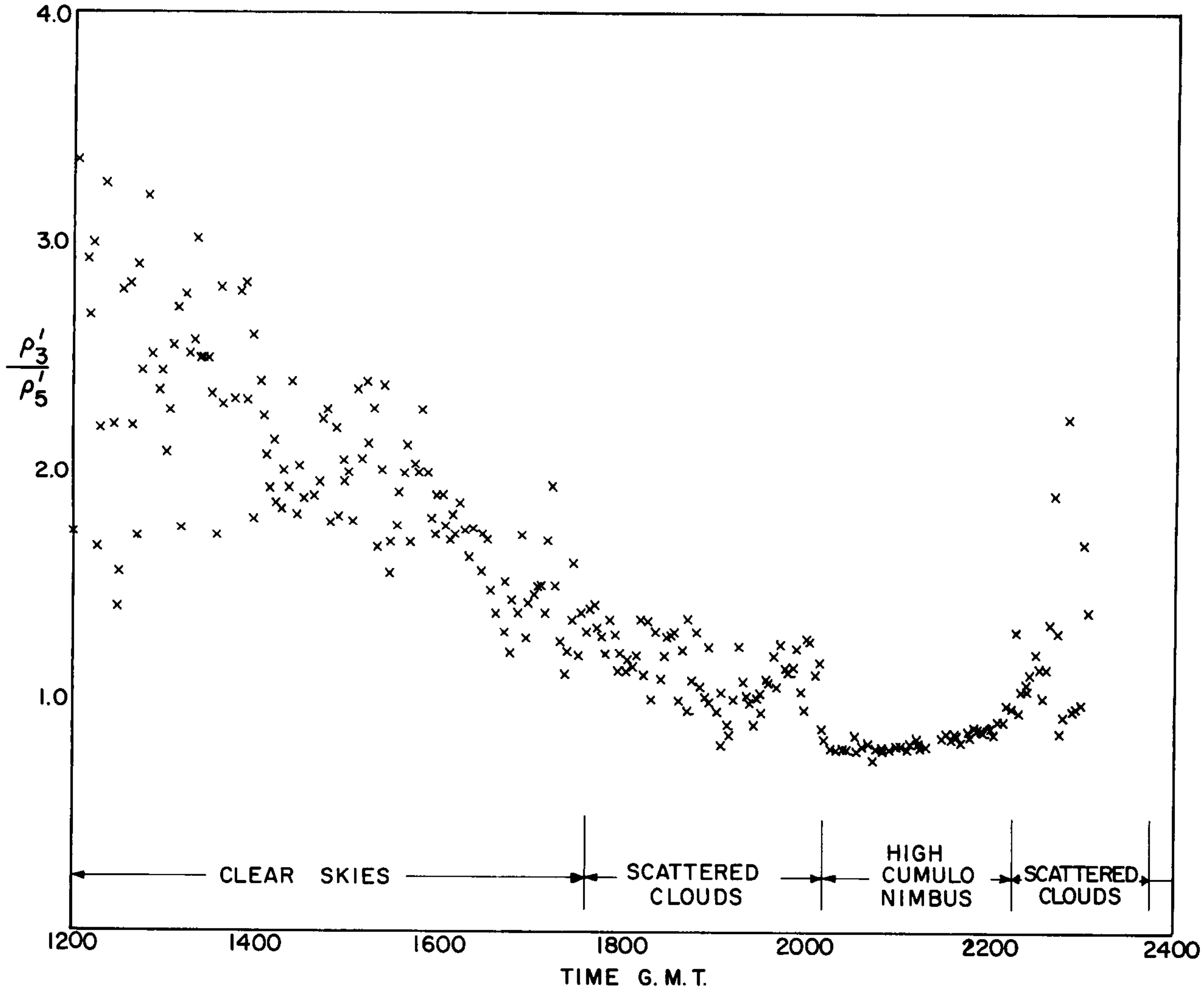


Figure 9. Reflectance ratio vs. time for 26 June, 1963 balloon flight NIMBUS MRIR F-1.

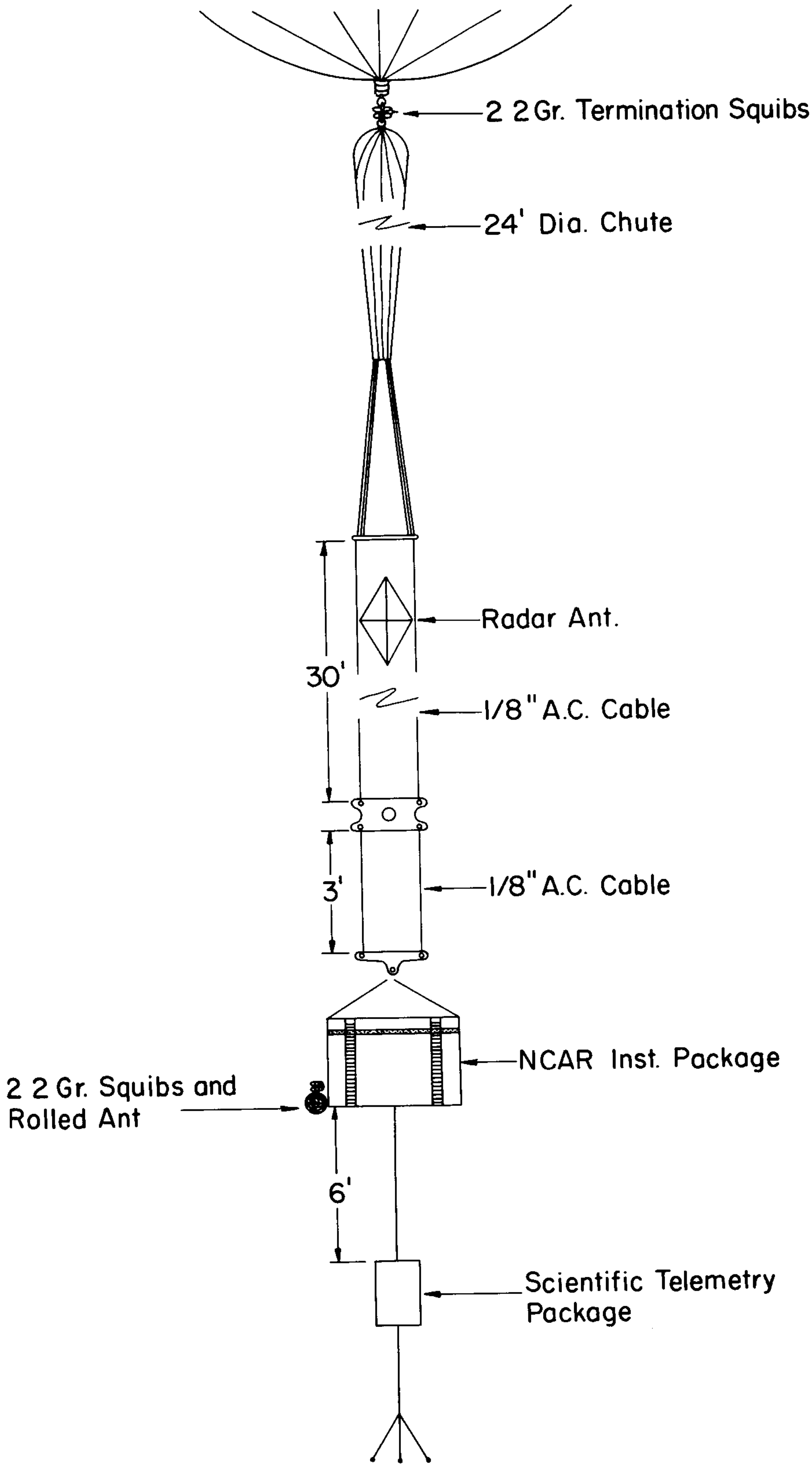


Figure 10. Balloon configuration, flight 213-P, 27 April, 1966.

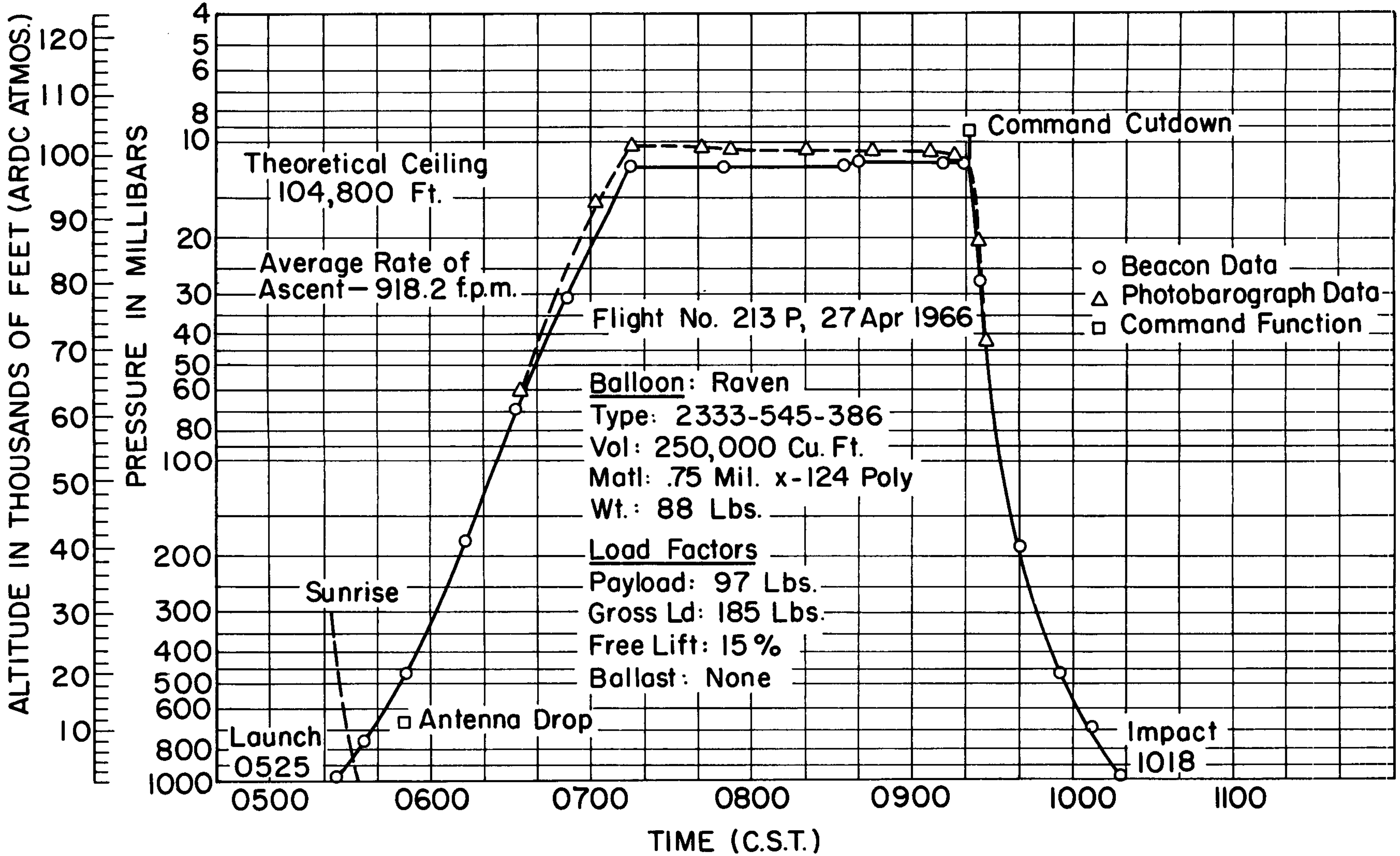


Figure 11. Altitude vs. time curve, flight 213-P, 27 April, 1966.

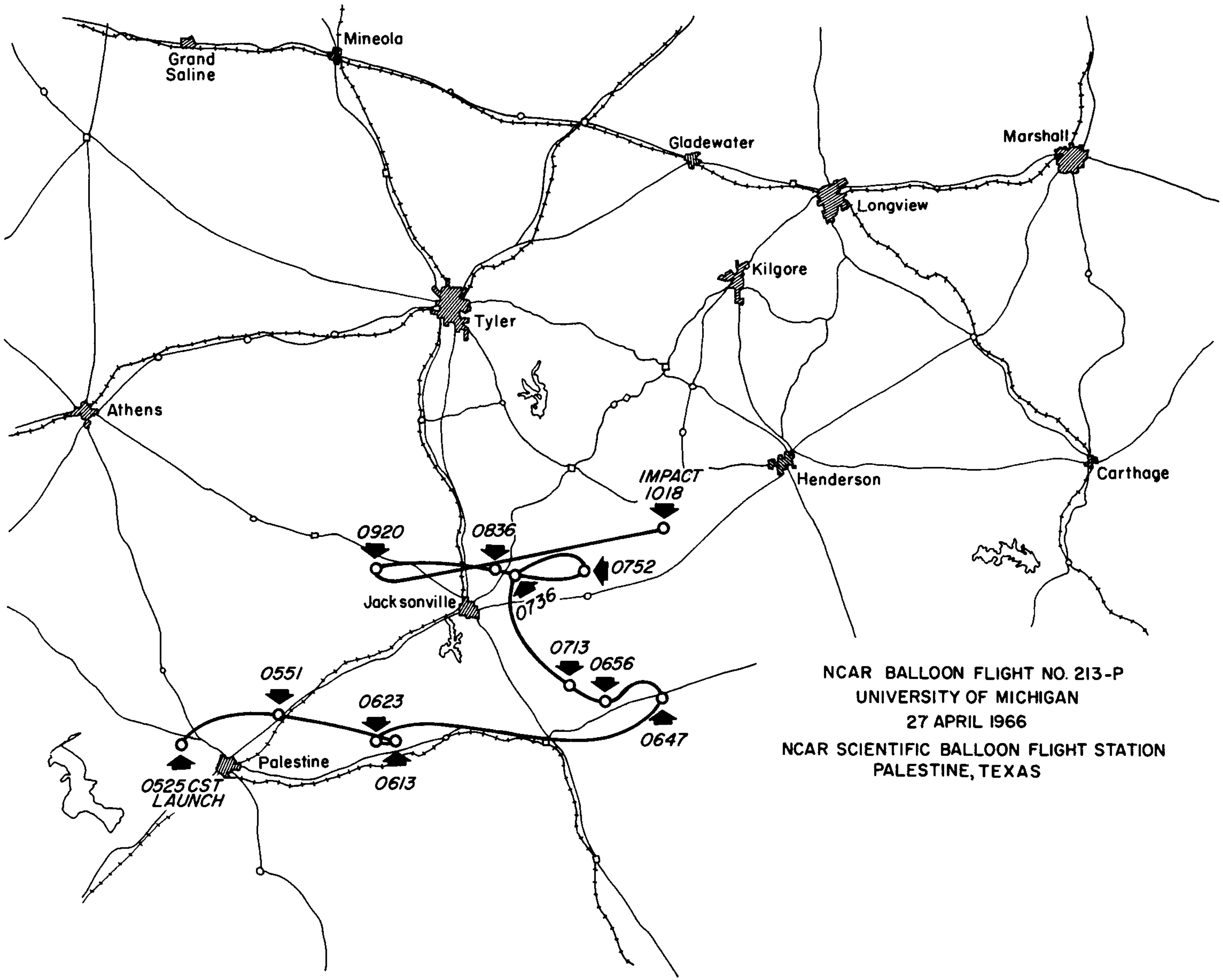


Figure 12. Trace of balloon trajectory on the earth, flight 213-P, 27 April, 1966.

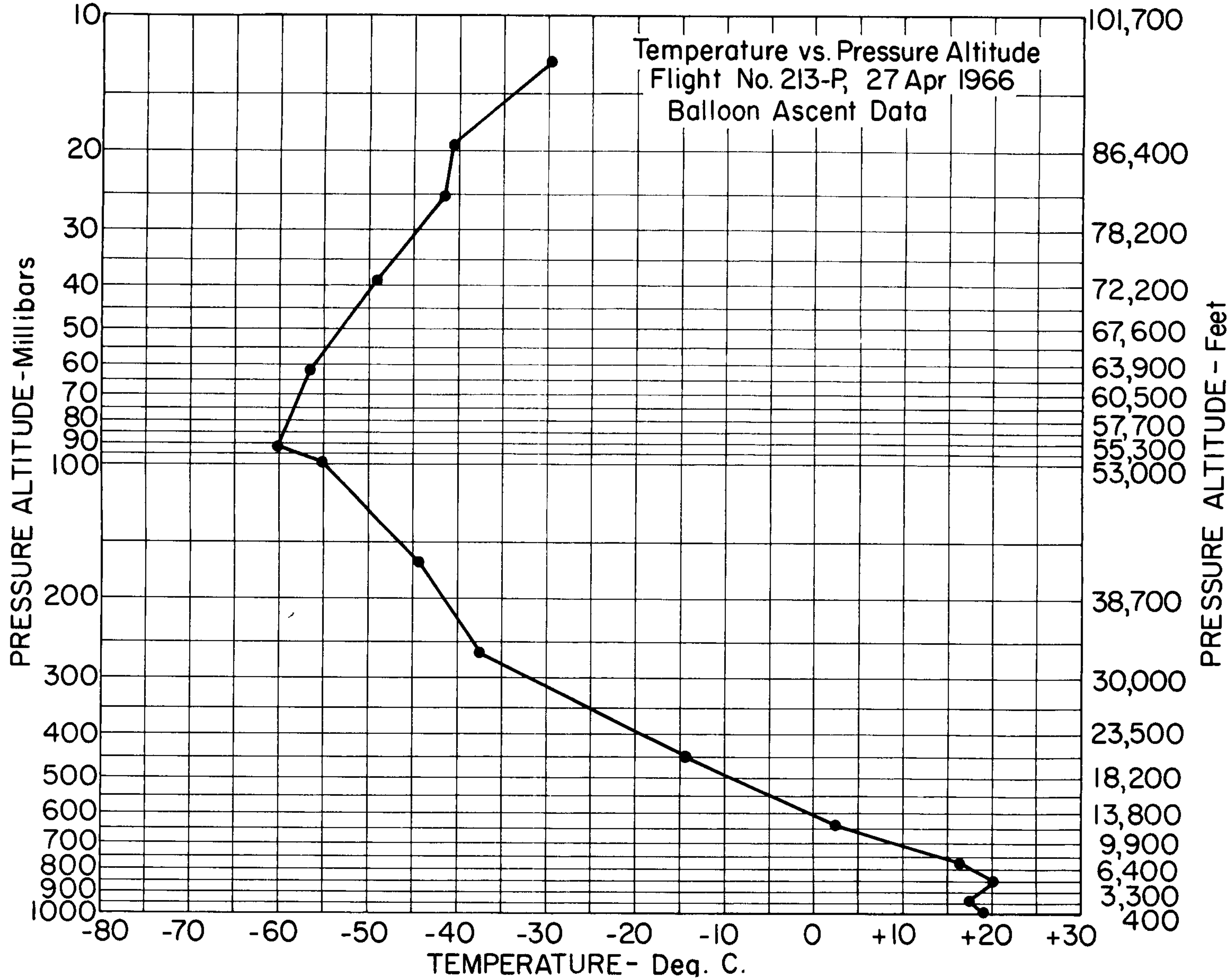


Figure 13. Air temperature data during balloon ascent, flight 213-P, 27 April, 1966.

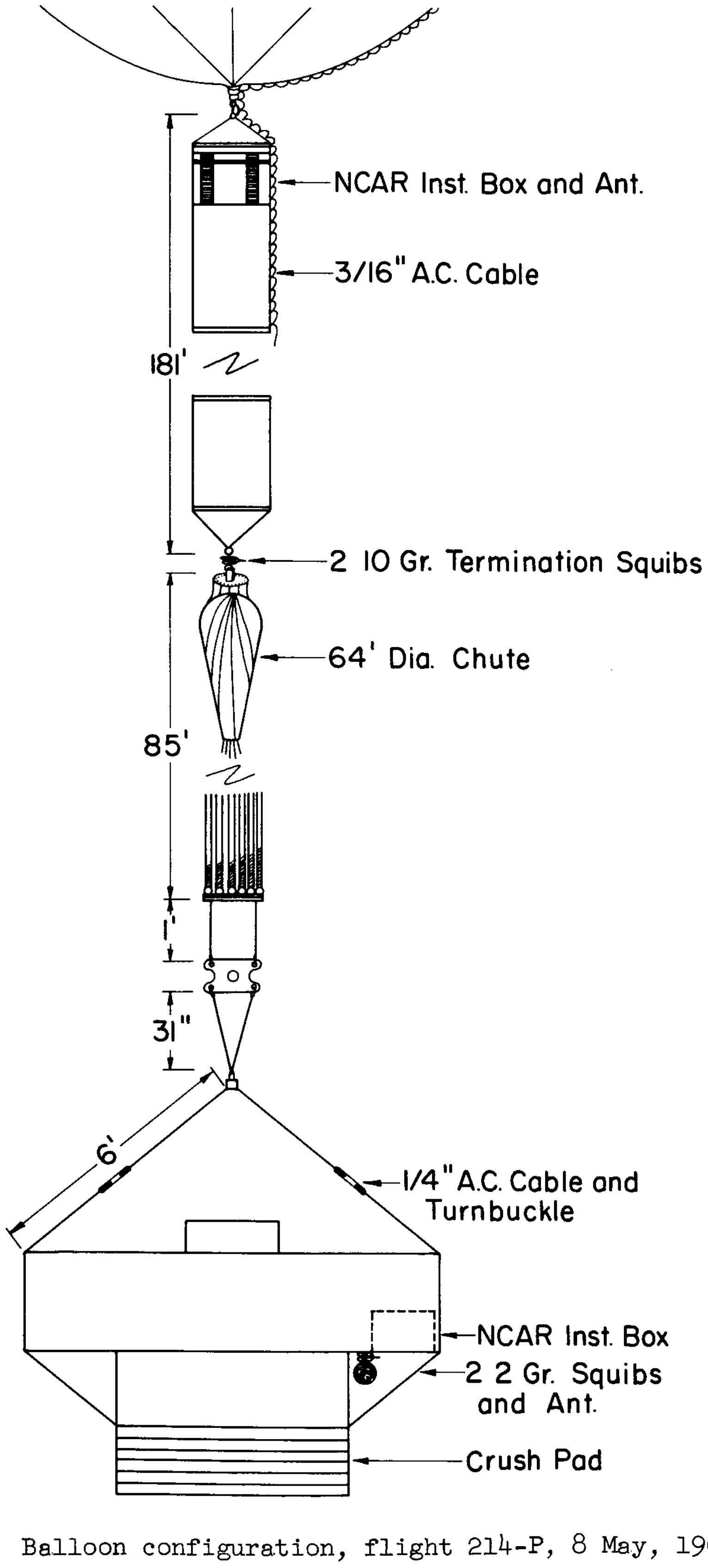


Figure 14. Balloon configuration, flight 214-P, 8 May, 1966.

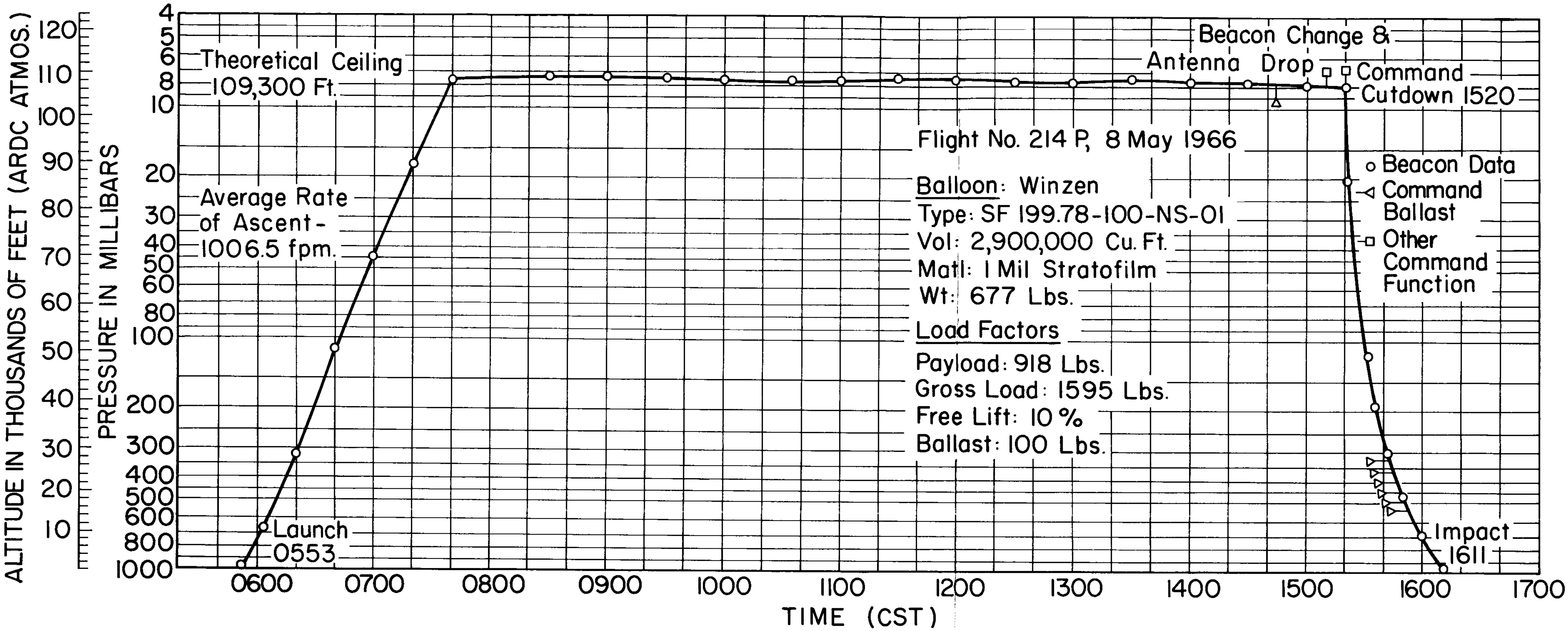
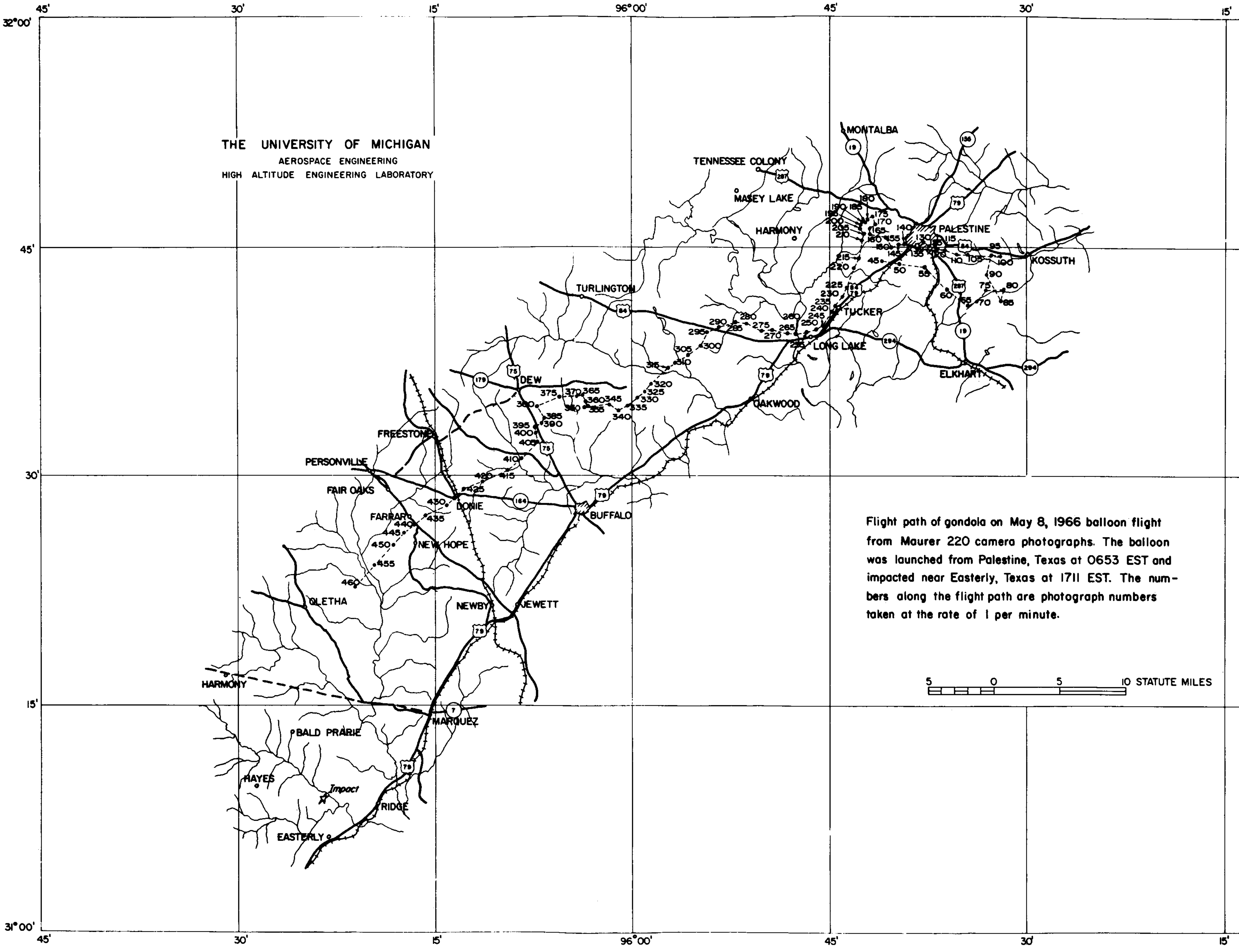


Figure 15. Altitude vs. time curve, flight 214-P, 8 May, 1966.

33-1

33-2



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90	081452
95	081952
100	082452
105	082952
110	083452
115	083952
120	084452
125	084952
130	
135	
140	
145	
150	
155	
160	
165	
170	
175	
180	
185	
190	
195	
200	
205	1052
210	1057
215	1102
220	1107
225	1112
230	1117
235	1122
240	1127
245	1132
250	1137
255	1142
260	1147
265	1152
270	1157
275	1202
280	1207
285	1212
290	1217
295	1222
300	1227
305	1232
310	1237
315	1242
320	1247
325	1252
330	1257
335	1302
340	1307
345	1312
350	1317
355	1322
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365	1332
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375	1342
380	1352
385	1357
390	1402
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Figure 16. Trace of balloon trajectory on earth, flight 214-P, 8 May, 1966.

34
-1

34
-2

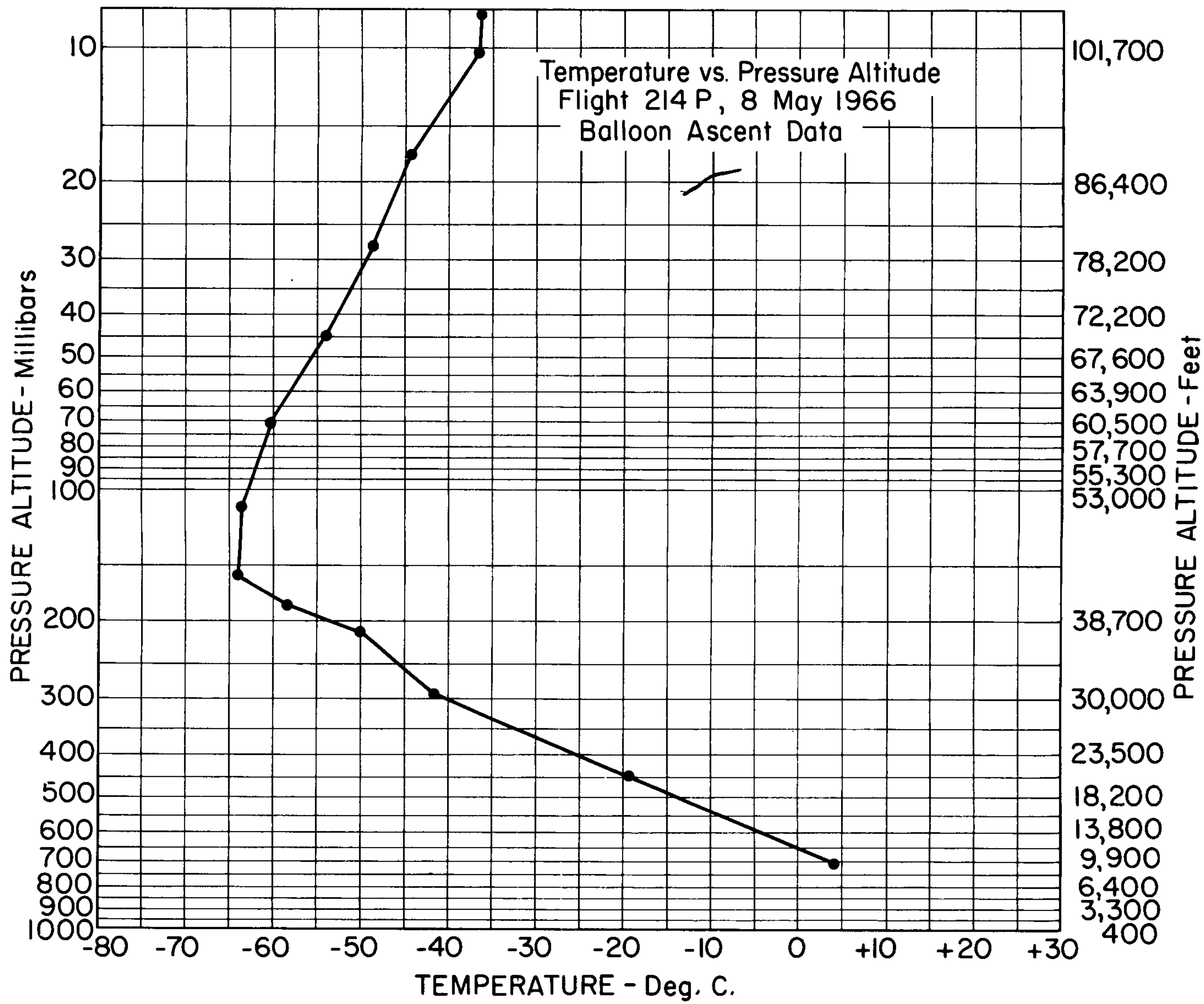

Figure 17. Air temperature data during balloon ascent, flight 214-P
8 May, 1966.

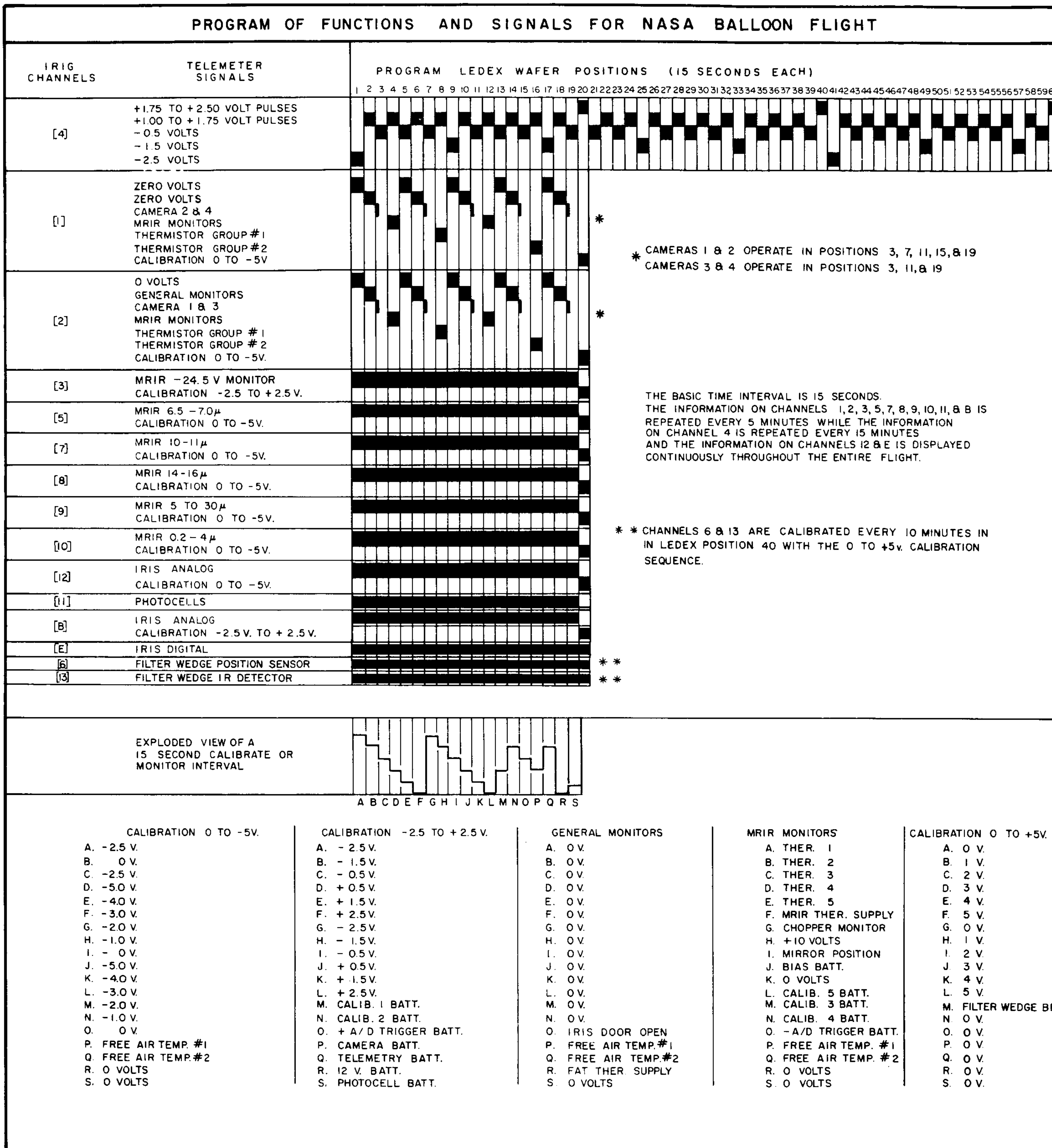

Figure 18. Program of functions and signals for 8 May, 1966 balloon flight.

Photo by JPL Staff Photographer, John Gregoire

Figure 19. Photograph of damaged gondola after 26 May, 1966 launch disaster.